

## Description

# [THIN FILM TRANSISTOR AND FABRICATING METHOD THEREOF]

### CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the priority benefit of Taiwan application serial no. 92118974, filed July 11, 2003.

### BACKGROUND OF INVENTION

[0002] Field of the Invention

[0003] The present invention relates to a semiconductor device and a method for fabricating the same. More particularly, the present invention relates to a structure of a thin film transistor (TFT) and a method for fabricating the same.

[0004] Description of the Related Art

[0005] A thin film transistor (TFT) typically includes a gate, a gate dielectric layer, a channel layer, a drain and a source, and is usually used as a switching device in a semiconductor apparatus. Since a TFT has a gate, a source and a drain, its operation is the same as that of a conventional MOS-

FET. The TFT family includes amorphous silicon( $\square$ -Si) TFT, which is formed by sequentially forming a gate, a gate dielectric layer, an  $\square$ -Si channel layer and a source/drain on a substrate. The gate is constituted of a single metal layer of aluminum (Al), chromium (Cr), tungsten (W), tantalum (Ta) or titanium (Ti), or constituted of multiple metal layers.

- [0006] However, when a single layer of aluminum or aluminum alloy is used to form the gate, the surface of the layer easily reacts with oxygen in the atmosphere to form aluminum oxide that cannot be effectively etched in the subsequent etching process. Therefore, a protective layer, such as a nitride layer, is usually formed on an aluminum or Al-alloy gate to prevent formation of aluminum oxide. However, such a method causes etching residues to form around the top of the gate during the etching process, resulting in an eave effect that will affect subsequent processes.
- [0007] On the other hand, when the gate is constituted of multiple metal layers including aluminum or aluminum alloy and other metals, such as chromium (Cr) or molybdenum (Mo), the underlying aluminum or Al-alloy layer having a higher etching rate is etched faster to produce undercuts

in the etching process. Furthermore, etching residues are also formed during the etching process of the multiple metal layers, so that an eaves effect is caused to raise the contact resistance and the wire resistance of the gate and lower the performance of the device. In addition, the process for forming multiple metal layers is surely more complicated than that for forming a single metal layer. Moreover, the above problems also occur in the process for forming the source/drain.

## SUMMARY OF INVENTION

- [0008] In view of the foregoing, this invention provides a thin film transistor (TFT) that includes a gate or a source/drain having a lower contact resistance or wire resistance.
- [0009] This invention also provides a method for fabricating a TFT that uses a material resistant to oxidation and erosion to form a single-layer gate or source/drain, so as to simplify the manufacturing process and improve the throughput.
- [0010] This invention further provides a method for fabricating a TFT to prevent formation of etching residues during the patterning/etching process of the gate or the source/drain.
- [0011] The method for fabricating a TFT of this invention is de-

scribed as follows. A gate is formed on a substrate, and an insulating layer is formed on the substrate covering the gate. A channel layer is formed on the insulating layer above the gate, and then a source/drain is formed on the channel layer to constitute a TFT. In this method, the gate or the source/drain includes a single layer of molybdenum–niobium (MoNb) alloy.

- [0012] Moreover, in the aforementioned method for fabricating a TFT, the gate may also be formed as a multi-layer structure of MoNb/AlNd or MoNb/AlNd/MoNb, wherein Nd represents neodymium element.
- [0013] The TFT structure of this invention includes a substrate, a gate, an insulating layer, a channel layer and a source/drain. The gate is disposed on the substrate, the insulating layer is disposed over the substrate covering the gate, and the channel layer is disposed on the insulating layer above the gate. The source/drain is disposed on the channel layer, and the gate or the source/drain includes a single MoNb layer.
- [0014] Moreover, in the aforementioned TFT structure, the gate can also be constituted of a multi-layer structure of MoNb/AlNd or MoNb/AlNd/MoNb.
- [0015] In addition, the amount of niobium in the MoNb alloy is

less than 10% in the above-mentioned TFT structure and the fabricating method thereof.

- [0016] Since the TFT process of this invention forms a single MoNb layer instead of the conventional AlNd/Cr or AlNd/Mo composite layer as the material of the gate or source/drain, the fabricating process of the gate or the source/drain can be simplified to improve the throughput.
- [0017] Moreover, since the MoNb alloy has a lower contact resistance and a lower wire resistance, the contact resistance and the wire resistance of the gate or the source/drain can be lowered.
- [0018] Furthermore, since the MoNb alloy is highly resistant to oxidation and erosion, no protective mask layer is needed during the etching process. Therefore, no etching residue is produced during the etching process.
- [0019] It is to be understood that both the foregoing general description and the following detailed description are exemplary, and are intended to provide further explanation of the invention as claimed.

#### **BRIEF DESCRIPTION OF DRAWINGS**

- [0020] The accompanying drawings are included to provide a further understanding of the invention, and are incorporated in and constitute a part of this specification. The

drawings illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention.

[0021] FIG. 1 illustrates a cross-sectional view of a TFT structure according to a preferred embodiment of this invention.

[0022] FIGs. 2A-2C illustrate a process flow of fabricating a TFT according to the preferred embodiment of this invention in a cross-sectional view.

#### **DETAILED DESCRIPTION**

[0023] This invention is further explained with an n-Si TFT and the fabricating process thereof as a preferred embodiment. However, the scope of this invention is not restricted to the contents of the preferred embodiment, and this invention can also be applied to the cases of LTPS (Low Temperature Poly-Silicon) TFT.

[0024] FIG. 1 illustrates a cross-sectional view of a TFT structure according to the preferred embodiment of this invention.

[0025] Referring to FIG. 1, a TFT structure of this invention includes a substrate 100, a gate 102, an insulating layer 104, a channel layer 106, a source 108a and a drain 108b. The gate 102 is disposed on the substrate 100, the insulating layer 104 is disposed over the substrate 100 covering the gate 102, and the channel layer 106 is disposed

on the insulating layer 104 above the gate 102. The source/drain 108a/b is disposed on the channel layer 106.

- [0026] The gate 102 is preferably based on a MoNb alloy, wherein the amount of niobium is less than 10%. The gate 102 can be a single MoNb layer, or a composite layer of MoNb/AlNd or MoNb/AlNd/MoNb, while the material of the source/drain 108a/b may be a conventional one like chromium (Cr).
- [0027] Besides, in another embodiment, the source/drain 108a/b is based on a MoNb alloy, wherein the amount of niobium is less than 10%. The source/drain 108a/b can be a single MoNb layer, or a composite layer of MoNb/AlNd or MoNb/AlNd/MoNb, while the gate 102 can be constituted of a conventional AlNd/Mo composite layer, for example. In still another embodiment, each of the gate 102 and the source/drain 108a/b is based on a MoNb alloy, wherein the amount of niobium is less than 10%. Each of the gate 102 and the source/drain 108a/b can be a single MoNb layer, or a composite layer of MoNb/AlNd or MoNb/AlNd/MoNb.
- [0028] It is noted that a MoNb alloy is more stable than pure chromium or pure molybdenum used in the prior art, and

is therefore more resistant to oxidation and erosion. The resistance to oxidation and erosion of a MoNb alloy can be enhanced by increasing the amount of niobium, but the electrical resistance of the MoNb alloy will be adversely raised with this method. Therefore, the amount of niobium should be moderately adjusted according to the requirements of the product.

- [0029] On the other hand, FIGs. 2A–2C illustrate a process flow of fabricating a TFT according to the preferred embodiment of this invention in a cross-sectional view.
- [0030] Referring to FIG. 2A, a substrate 100, such as a glass substrate or a transparent plastic substrate, is provided. A metal layer (not shown) having a thickness of thousands of angstroms is formed on the substrate 100 and then patterned to form a gate 102. The metal layer can be formed with a sputtering method, and can be a single MoNb layer or a composite layer of MoNb/AlNd or MoNb/AlNd/MoNb, wherein the amount of niobium in the MoNb alloy is less than 10%.
- [0031] Thereafter, a blanket insulating layer 104 is formed on the substrate 100 covering the gate 102. The insulating layer 104 is, for example, a silicon nitride layer or a silicon oxide layer that is formed with a plasma-enhanced chemical

vapor deposition (PECVD) process.

- [0032] Referring to FIG. 2B, a layer of channel material (not shown) is formed on the insulating layer 104 and then patterned into a channel layer 106 on the insulating layer 104 above the gate 102. The channel layer 106 is formed from  $\square$ -Si, for example, and can be provided with an ohmic contact layer thereon. The material of the ohmic contact layer is, for example,  $n^+$ -doped amorphous silicon.
- [0033] Referring to FIG. 2C, another metal layer (not shown) is formed over the substrate 100 and then patterned to form a source/drain 108a/b using a lithographic process and an etching process. The metal layer can be a single MoNb layer or a composite layer of MoNb/AlNd or MoNb/AlNd/MoNb, wherein the amount of niobium in the MoNb alloy is less than 10%. After the source/drain 108a/b is formed, the etching process is continued for a while to remove a portion of the exposed channel layer 106. With the above steps, a TFT constituted of a gate 102, an insulating layer 104, a channel layer 106 and a source/drain 108a/b is obtained.
- [0034] Several tests have been conducted to demonstrate the effects of this invention, wherein the gate or the source/

drain includes a single MoNb layer or a composite layer containing a MoNb layer, wherein the amount of niobium in the MoNb layer is less than 10%. The single MoNb layer or the composite layer is formed with a sputtering process conducted with an argon flow rate of 80sccm and a power of 55kW under 180°C. The testing results are listed in Tables 1 and 2.

Table 1: S/D Resistance

Material of Source/drain	Sheet resistance ( $\Omega/\text{cm}^2$ )	Contact resistance ( $\Omega/\text{cm}^2$ )
MoNb alloy (4000Å)	18.35	1.291
Cr (4000Å)	20.09	2.814
MoNb (450Å) / AlNd (2000Å) / MoNb (150Å)	10.92	1.31

[0035] As shown in Table 1, the sheet resistance and the contact

resistance of a source/drain constituted of a single MoNb layer are lower than those of a conventional chromium source/drain. The contact resistance of a source/drain constituted of a MoNb-containing composite layer is intermediate, and the sheet resistance of the same is lowest. Accordingly, using MoNb as the base material of the source/drain can actually reduce the contact resistance and the wire resistance of the source/drain.

Table 2: Gate Resistance

Material of Gate	Sheet resistance ( $\Omega/\text{cm}^2$ )	Contact resistance ( $\Omega/\text{cm}^2$ )
MoNb alloy (4000Å)	8.118	7.487
AlNd alloy (4000Å)	5.089	675.9
MoNb alloy (450Å) / AlNd alloy (2000Å)	4.597	34.76

[0036] As shown in Table 2, when the gate is constituted of a

single MoNb layer, the sheet resistance of the gate is higher than that of a conventional AlNd gate, but the contact resistance of the former is much lower than that of the latter. Moreover, both the sheet resistance and the contact resistance of the bilayer gate containing a MoNb layer are lower than those of a conventional AlNd gate.

Accordingly, using MoNb as the base material of the gate can actually reduce the contact resistance of the same.

[0037] As mentioned above, the gate or the source/drain can be constituted of a single MoNb layer or a composite layer of MoNb/AlNd or MoNb/AlNd/MoNb in the above embodiment. However, the gate or the source/drain is preferably constituted of a single MoNb layer, since the MoNb alloy is highly resistant to oxidation and erosion and has a relatively low contact resistance. By doing so, not only the contact resistance of the gate or the source/drain can be reduced, but also the fabricating process of the gate or the source/drain can be simplified.

[0038] Since the method of this invention uses a MoNb alloy having a lower contact resistance instead of conventional AlNd/Cr or AlNd/Mo as the base material of the gate or the source/drain, the contact resistance of the gate or the source/drain can be much reduced. Moreover, since the

MoNb alloy is more stable, no protective mask layer is needed in the patterning process of the gate or the source/drain.

- [0039] Moreover, since the gate can be constituted of a single MoNb layer instead of a composite metal layer, the TFT fabricating process can be simplified to increase the throughput.
- [0040] Furthermore, since no protective mask layer is formed before the etching process of the gate or the source/drain, no etching residue is formed during the etching process.
- [0041] It will be apparent to those skilled in the art that various modifications and variations can be made to the structure of the present invention without departing from the scope or spirit of the invention. In view of the foregoing, it is intended that the present invention covers modifications and variations of this invention provided they fall within the scope of the following claims and their equivalents.